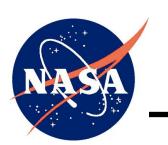# Precipitation Processing System (PPS)

Primer for Tropical Rainfall Measuring Mission (TRMM) Satellite Products in the Global Precipitation Measurement (GPM) Era

Moving from HDF4 to HDF5 Level 2 and Level 3 Products

Version 1.0

Prepared By:

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
Code 610.2/PPS
Greenbelt, Maryland 20771

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Goddard Space Flight Center
Greenbelt, Maryland

National Aeronautics and
Space Administration

TABLE OF CONTENTS

Primer for TRMM Satellite Products in the GPM Era:
Moving From HDF4 to HDF5 L2 and L3 Products
Version 1.0
Effective Date: May 2018

1.0   <u>OVERVIEW</u>

Tropical Rainfall Measuring Mission (TRMM) post-Version 7 products fully incorporate TRMM data into the Global Precipitation Measurement (GPM) mission data processing. TRMM Level 2 (L2) and Level 3 (L3) products have now become part of the GPM data suite. TRMM products are now in GPM HDF5 format and are labeled with product version V05A/V06A. For details on the algorithm caveats and product formats, please see Algorithm Release Notes and the full GPM Product File Specifications (http://pps.gsfc.nasa.gov). *This is a short introduction to some of the changes for those familiar with TRMM Version 7 products in HDF4 that may now need to read the data in the new HDF5 format.*

Reprocessed TRMM products will now be made available in formats similar to those used by GPM products and will use HDF5 (https://www.hdfgroup.org/). This is not simply a format change; new GPM-like retrieval algorithms are now used to process TRMM satellite instrument data.

Third-party tools such as IDL and MATLAB can read HDF5 files natively along with the PPS Tool for High-Resolution Observation Review (THOR) data viewer (https://pps.gsfc.nasa.gov/thorrelease.html). The PPS Science Algorithm Input/Output Toolkit (TKIO) (https://pps.gsfc.nasa.gov/gpmtoolkit.html) can also be used to read the product data for both HDF4 and HDF5 products. TRMM Version 7 products had a limitation in that field names needed to be unique within the product; with HDF5, that limitation has been lifted. The HDF5 files are generally structured into groups that are similar to file directories that can contain other groups or data arrays. For example, to access the data by field name, one can specify the full 'path' to a data array, example: '/NS/SLV/precipRate'.

Filename conventions for TRMM products in HDF5 follow those of GPM and can be found here (https://pps.gsfc.nasa.gov/Documents/FileNamingConventionForPrecipitationProductsForGPM Mission.pdf). The following table shows the mapping between TRMM Version 7 and the new HDF5 TRMM product designations.

TRMM Version 7 Designation	New TKIO ID	New Filename Prefix
2A21/2A23/2A25 (PR)	2APR	2A.TRMM.PR.
2A12 (TMI GPROF)	2ATMI	2A.TRMM.TMI.
2B31 (TRMM Combined)	2BCMBT	2B.TRMM.PRTMI.
3A25	3PR	3A-MO.TRMM.PR
3B31	3CMBT	3B-MO.TRMM.PRTMI
2H25	2HSLHT	2A.TRMM.PR.TRMM-SLH
3G25	3GSLHT	3A-ORBIT.TRMM.PR.TRMM-SLH
3H25	3HSLHT	3A-MO.TRMM.PR.TRMM-SLH
2H31	2HCSHT	2B.TRMM.PRTMI.2HCSHT
3G31	3GCSHT	3B-ORBIT.TRMM.PRTMI.3GCSHT
3H31	3HCSHT	3B-MO.TRMM.PRTMI.3GCSHT
3B42	3IMERGHH	3B-HHR.MS.MRG.3IMERG
3B43	3IMERGM	3B-MO.MS.MRG.3IMERG

Primer for TRMM Satellite Products in the GPM Era:
Moving From HDF4 to HDF5 L2 and L3 Products
Version 1.0
Effective Date: May 2018

The following sections give some details on major changes and a mapping for some commonly used fields in TRMM V7 products and the corresponding fields in the HDF5 products. Data can be downloaded from the NASA Precipitation Processing System (PPS) Web portal STORM (https://storm.pps.eosdis.nasa.gov/storm/) or directly by FTP (ftp://pps.gsfc.nasa.gov/). The FTP area will hold the old Version 7 TRMM data under /trmmdata while the new HDF5 TRMM products will appear under the /gpmdata directory.

2.0 <u>TMI L2 GPROF</u>

For TRMM Microwave Imager (TMI) L2 Goddard Profiling Algorithm (GPROF), file specification documents have to be read to understand the differences of fields between the two versions, even for fields that share the same name in the two versions.

TRMM Version 7 Field in HDF4	TRMM in GPM HDF5
Swath Fields	**S1 Fields**
	CAPE
qualityFlag	qualityFlag
	L1CqualityFlag
pixelStatus	pixelStatus
surfaceType	surfaceTypeIndex
	Temp2mIndex
landAmbiguousFlag	
landScreenFlag	
oceanExtendedDbase	
oceanSearchRadius	
chiSquared	
probabilityOfPrecip	probabilityOfPrecip
	mostLikelyPrecipitation
	precip1stTertial
	precip2ndTertial
sunGlintAngle	sunGlintAngle
freezingHeight	
surfacePrecipitation	surfacePrecipitation
	frozenPrecipitation
convectPrecipitation	convectPrecipitation
surfaceRain	
cloudWaterPath	cloudWaterPath
rainWaterPath	rainWaterPath
iceWaterPath	iceWaterPath
seaSurfaceTemperature	
totalPrecipitableWater	totalColumnWaterVaporIndex
	spare2
windSpeed	
freezingHeightIndex	
clusterNumber	profileNumber

Primer for TRMM Satellite Products in the GPM Era:
Moving From HDF4 to HDF5 L2 and L3 Products
Version 1.0
Effective Date: May 2018

TRMM Version 7 Field in HDF4	TRMM in GPM HDF5
	profileTemp2mIndex
clusterScale	profileScale
DataHeader Fields	**GprofHeader Fields**
cluster	clusterProfiles
heightLayerTop	hgtTopLayer
	speciesDescription
	temperatureDescriptions

3.0 <u>TMI L3</u>

The GPM Version 5 L3 TMI product is in the same format as the Version 5 L3 GPM Microwave Imager (GMI) and constellation products. The grid size is 0.25 degree and the coverage extends from 90°S to 90°N, while TRMM Version 7 (3A12) had grid size of 0.5 degree and 40°S to 40°N coverage. Variable changes from TRMM V7 to GPM V5 are listed below.

TRMM Version 7 Field in HDF4	TRMM in GPM HDF5
convectPrecipitation	/Grid/convectivePrecipitation
surfaceRain	
cldWater	/Grid/cloudWater
cldIce	/Grid/cloudIce
graupel	
latentHeat	
	/Grid/frozenPrecipitation
	/Grid/fractionQuality3
	/Grid/surfaceTypeIndex
	/Grid/cloudWaterPath
	/Grid/rainWaterPath
	/Grid/iceWaterPath

4.0 <u>PR L2 PRECIPITATION RETRIEVAL</u>

The Precipitation Radar (PR) L2 Precipitation Retrieval algorithm is very similar to that used in GPM for the Ku-band (Ku) radar with a similar output format. The measured reflectivity (Zm) is now in the L2 product; there is no longer a 1C product.

The vertical binning has changed. The L2 product has 125m slant range bins with bin 176 (1-based) containing the Earth Ellipsoid.

Primer for TRMM Satellite Products in the GPM Era:
Moving From HDF4 to HDF5 L2 and L3 Products
Version 1.0
Effective Date: May 2018

TRMM Version 7 Field in HDF4	TRMM in GPM HDF5
e_surfRain	/NS/SLV/precipRateEstimatedSurface
nearSurfRain	/NS/SLV/precipRateNearSurface
rain	/NS/SLV/precipRate
rainType	/NS/CSF/precipType
correctZFactor	/NS/SLV/zFactorCorrected
1C: normalSample (containing Zm)	/NS/PRE/zFactorMeasured
1C: minechoFlag	/NS/PRE/precipFlag

5.0 **PR L3**

The L3 product is in the same format as the L3 Dual-Frequency Precipitation Radar (DPR), which contains multiple indices for the Ku, Ka-band (Ka), and DPR retrievals. Since PR is a single-frequency radar, the arrays corresponding to non-Ku frequency data are set to Missing Values. In addition, gridded products are now produced daily for Ascending and Descending parts of the orbit. These daily products are used as input to the monthly gridded L3. The new HDF5 products have two grid sizes: 0.5 deg. and 5.0 deg. Both of these grids are contained in the HDF5 product under /Grids/G1 and /Grids/G2, respectively.

The format of the HDF5 statistics generally follows a grouping consisting of the mean, count, standard deviation, and a histogram.

The TRMM Version 7 product had named fields for separate Convective and Stratiform statistics. The HDF5 product now has these included as indices in the multi-dimensional arrays. Typically, they are separated as Stratiform, Convective, and All. In addition, the HDF5 has statistics for surface types separated within indices as Land, Ocean, and All.

TRMM Version 7 Field in HDF4	TRMM in GPM HDF5
ttlPix1	/Grids/G1/observationCounts
e_surfRainMean1	/Grids/G1/precipRateESurface/mean
E_surfRainPix1	/Grids/G1/precipRateESurface/counts
rainMean1	/Grids/G1/precipRate/mean

Primer for TRMM Satellite Products in the GPM Era:
Moving From HDF4 to HDF5 L2 and L3 Products
Version 1.0
Effective Date: May 2018

6.0 <u>COMBINED L2</u>

2B31 -> 2BCMBT

TRMM Version 7 Field in HDF4	TRMM in GPM HDF5
dHat - Mean drop diameter (mm) x 100	/NS/precipTotPSDparamLow, /NS/precipTotPSDparamHigh - Particle size distribution, parameters Nw and Dm, see 2BCMB Algorithm Theoretical Basis Document (ATBD)
rHat - Instantaneous rain rate (liquid only) at the radar range gates (mm/hour) x 10	/NS/precipTotRate (mm/hour) * /NS/liqRateFracTrans
graupel - Graupel content estimated at the radar range gates (g/m^3) x 1000 plus snow - Snow content estimated at the radar range gates (g/m^3) x 1000	/NS/precipTotWaterCont * (1 - /NS/liqMassFracTrans) (g/m^3) (total precipitating ice)
rrSurf - Surface rainfall rate (liquid only) (mm/hour)	/NS/SurfPrecipTotRate (mm/hour) * /NS/surfLiqRateFrac
prSurf - Surface precipitation rate (liquid plus solid) (mm/hour)	/NS/SurfPrecipTotRate (mm/hour)

7.0 <u>COMBINED L3</u>

3B31 -> 3CMBT

For all TMI, see Level 3 TRMM TMI in GPM V05.

TRMM Version 7 Field in HDF4	TRMM in GPM HDF5
surfacePrecipCOMB - Surface precipitation from the narrow swath of 2B31 (mm)	/G1/surfPrecipTotRateUn, /G2/surfPrecipTotRateUn (mm/hour)
rainWaterCOMB - Monthly mean rain water content from the narrow swath of 2B31 at each vertical layer (g/m^3)	/G1/precipLiqWaterContent.mean * /G1/precipLiqWaterContent.count / /G1/precipAllObs, /G2/precipLiqWaterContent.mean * /G2/precipLiqWaterContent.count / /G2/precipAllObs (g/m^3) (unconditional mean liquid rain water content)
snowCOMB - Monthly mean snow liquid water content from the narrow swath of 2B31 at each vertical layer (g/m^3) plus graupelCOMB - Monthly mean graupel liquid water content from the narrow swath of 2B31 at each vertical layer (g/m^3)	{/G1/precipTotWaterContent.mean * /G1/precipTotWaterContent.count / /G1/precipAllObs} - {/G1/precipLiqWaterContent.mean * /G1/precipLiqWaterContent.count / /G1/precipAllObs}, {/G2/precipTotWaterContent.mean * /G2/precipTotWaterContent.count / /G2/precipAllObs} -

Primer for TRMM Satellite Products in the GPM Era:
Moving From HDF4 to HDF5 L2 and L3 Products
Version 1.0
Effective Date: May 2018

TRMM Version 7 Field in HDF4	TRMM in GPM HDF5
	{/G2/precipLiqWaterContent.mean * /G2/precipLiqWaterContent.count / /G2/precipAllObs} (g/m^3) (unconditional mean total ice-phase precipitation)
npixTotalCOMB - The monthly number of pixels per grid box	/G1/precipAllObs, /G2/precipAllObs
surfAdjRatio	Not calculated
surfAdjRatioOverlap	Not calculated

8.0 L3 TMPA/IMERG

The TRMM Multisatellite Precipitation Analysis (TMPA) grid of 50°S-50°N at 0.25° latitude and longitude is replaced by the Integrated Multisatellite Retrievals for GPM (IMERG) grid of 90°S-90°N at 0.10°. The 3B42 3-hour product is replaced by the IMERG half-hour product.

If not listed below, variables have the same name but are preceded by the path "/Grid/". For example, "gaugeRelativeWeighting" in TRMM 3B43 becomes "/Grid/gaugeRelativeWeighting" in the GPM monthly IMERG.

TRMM V7	TRMM in GPM HDF5
precipitation (in 3B42)	/Grid/precipitationCal
relativeError	/Grid/randomError
satPrecipitationSource	/Grid/HQprecipSource
satObservationTime	/Grid/HQobservationTime

9.0 L2 CSH/CSSH

For L2 Convective Stratiform Heating (CSH) and Convective Stratiform Synoptic Heating (CSSH), the TRMM 19 layers are replaced by the GPM 80 layers.

If not listed below, variables in TRMM 2H31 have the same name but are preceded by the path "/Swath/" in the GPM 2H products. Thus "latentHeating" in TRMM 2H31 becomes "/Swath/latentHeating" in GPM 2H CSSH.

TRMM V7	TRMM in GPM HDF5
scanTime_sec	/Swath/ScanTime/SecondOfDay

Primer for TRMM Satellite Products in the GPM Era:
Moving From HDF4 to HDF5 L2 and L3 Products
Version 1.0
Effective Date: May 2018

10.0 L3 CSH/CSSH

For L3 CSH/CSSH, the TRMM 19 layers are replaced by the GPM 80 layers. The horizontal grids are unchanged.

All variables in TRMM 3G31 and 3H31 have the same name but are preceded by the path "/Grid/" in the GPM 3G and 3H products. Thus "latentHeating" in 3H31 becomes "/Grid/latentHeating" in the GPM 3H CSSH.

11.0 L2 SLH

For L2 Spectral Latent Heating (SLH), the TRMM 19 layers are replaced by the GPM 80 layers.

If not listed below, variables in TRMM 2H25 have the same name but are preceded by the path "/Swath/" in GPM 2H SLH. Thus "latentHeating" in TRMM 2H25 becomes "/Swath/latentHeating" in GPM 2H SLH.

TRMM V7	TRMM in GPM HDF5
scanTime_sec	/Swath/ScanTime/SecondOfDay
rainType2A25	/Swath/rainType2APR

12.0 L3 SLH

For L3 SLH, the TRMM 19 layers are replaced by the GPM 80 layers. The TRMM grid of 37°S-37°N is replaced by the GPM grid of 67°S-67°N.

If not listed below, variables in TRMM 3G25 and 3H25 have the same name but are preceded by the path "/Grid/" in the GPM 3G and 3H products. Thus "allPix" in TRMM 3H25 becomes "/Swath/allPix" in GPM 3H SLH.

Parts of most variable names have changed:

"shallow" becomes "shstr",
"strat" becomes "dpstr",
"Dev" becomes "Stdv",
add "Cnd" before "Mean" or "StDv".

TRMM V7	TRMM in GPM HDF5
allLHMean	/Grid/allLHCndMean
allQ1RMean	/Grid/allQ1RCndMean
allQ2Mean	/Grid/allQ2CndMean
LHMean	/Grid/LHCndMean
LHDev	/Grid/LHCndStdv
convLHMean	/Grid/convLHCndMean
convLHDev	/Grid/convLHCndStdv

Primer for TRMM Satellite Products in the GPM Era:
Moving From HDF4 to HDF5 L2 and L3 Products
Version 1.0
Effective Date: May 2018

TRMM V7	TRMM in GPM HDF5
stratLHMean	/Grid/dpstrLHCndMean
stratLHDev	/Grid/dpstrLHCndStdv
shallowLHMean	/Grid/shstrLHCndMean
shallowLHDev	/Grid/shstrLHCndStdv
LHMean	/Grid/Q1RCndMean
LHDev	/Grid/Q1RCndStdv
convLHMean	/Grid/convQ1RCndMean
convLHDev	/Grid/convQ1RCndStdv
stratLHMean	/Grid/dpstrQ1RCndMean
stratLHDev	/Grid/dpstrQ1RCndStdv
shallowLHMean	/Grid/shstrQ1RCndMean
shallowLHDev	/Grid/shstrQ1RCndStdv
LHMean	/Grid/Q2CndMean
LHDev	/Grid/Q2CndStdv
convLHMean	/Grid/convQ2CndMean
convLHDev	/Grid/convQ2CndStdv
stratLHMean	/Grid/dpstrQ2CndMean
stratLHDev	/Grid/dpstrQ2CndStdv
shallowLHMean	/Grid/shstrQ2CndMean
shallowLHDev	/Grid/shstrQ2CndStdv

Primer for TRMM Satellite Products in the GPM Era:
Moving From HDF4 to HDF5 L2 and L3 Products
Version 1.0
Effective Date: May 2018

ACRONYMS

ATBD	Algorithm Theoretical Basis Document
CMB	Combined
CSH	Convective Stratiform Heating
CSSH	Convective Stratiform Synoptic Heating
DPR	Dual-Frequency Precipitation Radar
GMI	GPM Microwave Imager
GPM	Global Precipitation Measurement (Mission)
GPROF	Goddard Profiling Algorithm
HDF	Hierarchical Data Format
IDL	Interactive Data Language
IMERG	Integrated Multisatellite Retrievals for GPM
Ku/Ka	Ku-band/Ka-band
L2/L3	Level 2/Level 3
PPS	Precipitation Processing System
PR	Precipitation Radar
SLH	Spectral Latent Heating
THOR	Tool for High-Resolution Observation Review
TKIO	PPS Science Algorithm Input/Output Toolkit
TMI	TRMM Microwave Imager
TMPA	TRMM Multisatellite Precipitation Analysis
TRMM	Tropical Rainfall Measuring Mission
Zm	Measured Reflectivity